

MINERALOGICAL NOTES: No. III.—AXINITE,
PETTERDITE, CROCOITE, AND DATOLITE.

By C. ANDERSON, M.A., B.Sc., Mineralogist.

(Plates xxix.—xxxiii.).

AXINITE.

BOWLING ALLEY POINT, NEAR NUNDLE, NEW SOUTH WALES.

(Plate xxix.).

Axinite was first found at this locality by Mr. D. A. Porter,¹ to whom I am indebted for notes as to its mode of occurrence. The exact location is about a quarter of a mile from the foot-bridge over the Peel River, where the mineral is found associated with green epidote in sedimentary rocks much altered by intrusive diorite: it occurs sometimes in crystalline veins, but the best specimens are obtained in cavities, where the crystals have grown freely, accompanied by small well-formed quartz prisms. Good crystals are rare and minute; larger, more imperfect ones can be found measuring up to 15 mm. The colour is brownish with a violet tinge on a fresh fracture.

Three of the best crystals, each measuring about 3 mm., were removed from the matrix, and their faces determined on a two-circle goniometer; owing to their mode of attachment the crystals were fractured in removal along a line roughly parallel to the edge *b c* (Pl. xxix., figs. 3, 4). After several trials the habit was made out, but it was found impracticable owing to the small size and unsatisfactory nature of the prism faces to centre the crystals in the conventional position; instead, the most prominent zone—either $[010, 111]$ or $[1\bar{3}0, 021]$ —was made equatorial and the available angles determined, after which the crystal was inverted, and, with the same zone as before equatorial, the angles yielded by the faces on the other end measured. By plotting the co-ordinates in stereographic projection, the forms were easily identified by the aid of Penfield's invaluable protractors. From the measurements, the normal angles were calculated for comparison with the theoretical values calculated from Goldschmidt's "Winkeltabellen."² This method, though it does not afford direct comparison of measured with calculated angles, is sufficient to prove the correctness of identification.

In habit the crystals are uniformly tabular on *c* ($1\bar{1}1$), which

¹ Liversidge—Journ. Roy. Soc. N.S. Wales, xviii., 1884 (1885), p. 45;

Porter—*Ibid.*, xxii., 1888 (1889), p. 82.

² Goldschmidt—Kristallographische Winkeltabellen, 1877, p. 58.

is the only large face; it is strongly striated parallel to its intersection with M ($\bar{1}\bar{1}0$), and gives a multiple and blurred image.

I have adopted Dana's position and lettering, converting Goldschmidt's indices by the transformation equations, $h' = -h$, $k' = 2h + k$, $l' = l$, where the dashed letters refer to Dana's indices. A table showing the equivalent letters and indices according to Dana and Goldschmidt respectively will be found below, p. 137, under the description of axinite from Colebrook Tasmania.

The following table of angles is constructed from measurements on the specimen shown in Pl. xxix., fig. 4 (which gives the best reflections), with the exception of the angles $M \wedge z$, $w \wedge Y$ and $w \wedge f$, which were got from the crystal drawn in orthogonal and clinographic projection in Pl. xxix., figs. 1 and 2.

Forms.	Calculated from Measurements.		Calculated from Winkeltabellen.		Difference.
	o	r	o	r	
$h : m = 010 : 110$	32	41	32	54	13
: $M = \quad : \bar{1}\bar{1}0$	77	29	77	30	1
: $w = \quad : \bar{1}\bar{3}0$	137	56	137	46	10
: $x = \quad : 111$	46	2	45	58	4
: $r = \quad : \bar{1}\bar{1}1$	87	7	86	47	20
: $u = \quad : \bar{1}\bar{3}1$	130	39	130	29	10
$m : s = 110 : 201$	28	6	28	0	6
: $r = \quad : \bar{1}\bar{1}1$	65	6	64	23	43
$M : r = \bar{1}\bar{1}0 : \bar{1}\bar{1}1$	45	25	45	12	13
: $z = \quad : \bar{1}\bar{1}2$	63	45	63	34	11
: $e = \quad : 001$	89	48	89	55	7
$w : d = \bar{1}\bar{3}0 : \bar{2}\bar{4}1$	31	43	31	44	1
: $r = \quad : \bar{1}\bar{1}1$	64	14	64	13	1
: $y = \quad : 021$	123	40	123	6	34
: $u = \quad : \bar{1}\bar{3}1$	32	32	32	27	5
: $e = \quad : 001$	82	58	83	6	8
: $o = \quad : \bar{1}\bar{3}2$	121	12	121	6	6
: $Y = \quad : \bar{1}\bar{3}1$	142	47	143	2	15
: $f = \quad : 011$	108	8	108	30	22

MOONBI, NEW SOUTH WALES.

(Plate xxxi., figs. 1, 2).

Axinite was recorded from this locality by Mr. D. A. Porter³ in 1884; at that time its occurrence *in situ* was not known, but recently Mr. Porter has traced it to its parent rock at a point about two miles south-east from Moonbi Railway Station. The mode of occurrence is practically the same as that of the Bowling Alley Point axinite: from a genetic point of view the two are probably identical.

One of the Museum specimens is fully as large as one's fist, and entirely composed of somewhat coarse crystals which are often built up of several individuals in approximately parallel position, recalling the sheaf-like aggregates so common with stilbite. Smaller crystals adapted for goniometric determination were obtained from crevices, where, as at Bowling Alley Point, they are accompanied by crystallised quartz.

Two fragmentary crystals, each between 2 and 3 mm. long, were measured, and drawn (Pl. xxxi., figs. 1, 2) according to their natural development. The zone [010, 111] was made equatorial as before, and the normal angles obtained by calculation from the measured co-ordinates. The habit is similar to that of the Nundle axinite, and r ($\bar{1}\bar{1}1$) is, as in that, striated parallel to its intersection with M ($1\bar{1}0$).

COLEBROOK MINE, DUNDAS, TASMANIA.

(Plate xxx. ; Pl. xxxi., fig. 3).

This occurrence was first put on record by Messrs. Petterd and Twelvetrees in their paper "On the Occurrence of Limurite in Tasmania."⁴ In that paper and two supplementary notes⁵ the authors have discussed the field relations and microscopic characters of this interesting axinite-bearing rock, which is paralleled only by the original limurite of the Pyrenees.⁶

³ Porter—Journ. Roy. Soc. N.S. Wales, xviii., 1884 (1885), p. 80.

⁴ Petterd and Twelvetrees—Proc. Roy. Soc. Tas., 1897 (1898), pp. 1-6, pl.

⁵ Petterd and Twelvetrees—*Loc. cit.*, 1898-9 (1900), pp. 1, 2 and 56-59.

⁶ Zirkel—Neues Jahrb. für Min., 1879, p. 379.

The locality is North-east Dundas between Ringville and Rosebery, where the limurite forms a lenticular contact mass bounded on the east by slate of probably Silurian age, and on the west by serpentine.

From hand specimens in the Museum collection it appears that the macroscopic associates of axinite are calcite chiefly in veins, chalcOPYrite, pyrrhotite, actinolite in radiating aggregates, and datolite in crystalline masses. To this list Petterd and Twelve-trees from microscopic examination add chlorite, tourmaline, danburite and sphene, while they find that the main mass of the rock is a pyroxenite which here and there receives accessions of axinite and other minerals, thereby becoming "limurite."

The axinite occurs as well-defined crystals, sometimes reaching a length of 15 or 16 mm., embedded in calcite or datolite and disseminated through the pyroxene. It is not easy to find a detachable crystal suitable for the goniometer, and I am indebted to Mr. W. F. Petterd for the loan of three crystals, each fragmentary but better than any in our collection and adequate for measurement. The colour is clove brown; the specific gravity, determined on a crystal weighing 1.0085 gram, was found to be 3.270.

The habit recalls that of the Nundle and Moonbi axinite, the specimens having the same tabular extension parallel to r ($1\bar{1}1$). Here however z ($1\bar{1}2$) is also a face of considerable size; both r and z are deeply striated parallel to their intersection. The prism faces are not prominent and are slightly striated parallel to the vertical axis.

The crystal from which the figures were made measures approximately 8 mm. in greatest diameter; it is broken across in the direction of the edge r z . After preliminary "one-circle" measurement in two zones, several faces were identified and the habit made out; the crystal was then mounted with the prism zone normal to the vertical circle, and the co-ordinate angles obtained. With the exception of r and z , which have both faces present, all the forms were determined from single planes; the faces f (011), g (021) and Y ($1\bar{3}1$) gave no distinct signal and were measured in the position of brightest illumination. Owing to the difficulty of accurately centring, and the small size and imperfections of some of the faces, the measured and calculated angles do not always agree closely.

In the table below the calculated angles are taken from Goldschmidt's "Winkeltabellen," but Dana's position and lettering have been adopted as before.

Form.		Measured.		Calculated.		Difference.	
Goldschmidt.	Daup.	ϕ	ρ	ϕ	ρ	ϕ	ρ
<i>m</i>	001	-89	7	-90	7	1	35
<i>c</i>	110	0	90	0	90	0	12
<i>M</i>	010	(102 30)	90	102	90	—	16
<i>w</i>	130	60	90	60	90	17	31
<i>u</i>	110	134	90	135	90	45	16
<i>l</i>	100	152	90	151	90	55	52
<i>z</i>	112	-164	26	-164	27	5	40
<i>r</i>	111	-172	44	-172	45	2	27
<i>f</i>	011	103	25	106	27	3	12
<i>a</i>	021	103	48	104	49	1	29
<i>b</i>	021	-78	23	-78	46	2	16
δ	132	-115	31	-115	40	2	24
<i>Y</i>	131	56	54	57	53	8	57
<i>x</i>	111	137	46	138	48	1	13
<i>u</i>	131	-117	29	-117	16	1	10
<i>s</i>	201	153	30	153	49	19	3
<i>d</i>	241	-140	20	-140	52	32	50
<i>q</i>	151	78	48	79	33	45	39

PETTERDITE NOT A NEW MINERAL.

(Plate xxxi., fig. 4 ; Pl. xxxii.).

In 1901 Mr. W. H. Twelvetrees, Government Geologist of Tasmania, described under the name petterdite (in honour of Mr.

W. F. Petterd, of Launceston) a supposed new oxychloride of lead, which was found in the upper workings of the Britannia Mine, Zeehan, Tasmania, as groups of white hexagonal plates in a quartz gangue containing disseminated pyrites; the analysis was made by Mr. O. E. White of Hobart.⁷ Some time back Mr. Petterd kindly lent me for examination his best specimen (Pl. xxxii.), also some detached crystals; on a chemical and crystallographic study of this material the following conclusions are based.

For a description of the physical characters I may refer to the original account which is substantially correct: no macles however were observed, and the hardness is not 1·5 as stated, but lies between 3 and 4, the mineral being harder than calcite and softer than fluorite.

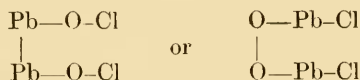
Crystallography. Three crystals, each about 4 mm. in diameter were measured on a two-circle goniometer. The angles obtained are only approximate, as the faces are interrupted, wavy and slightly curved, usually yielding only a vague patch of light in the telescope. The basal plane is rough and gives no reflection, therefore the crystals were centred by the prism faces. The system is hexagonal, the forms present being c (0001), the prism (10 $\bar{1}$ 0), and the first and second order pyramids (10 $\bar{1}$ 1) and (11 $\bar{2}$ 1). Pyramidal faces do not occur on all the crystals and the pyramid (10 $\bar{1}$ 1) is the commoner and better developed.

From the measurement $0001 \wedge 10\bar{1}1 = 38^\circ 42'$ the length of the vertical axis was found to be ·6938. The measured angle $0001 \wedge 11\bar{2}1$ is $53^\circ 20'$, calculated $54^\circ 13'$.

Composition. In the endeavour to discover, if possible, the affinities of this apparently new species, the original analysis given below was more closely scanned.

Pb O	...	...	...	74·04 %
As ₂ O ₅	...	...	...	2·60
P ₂ O ₇ [<i>sic</i>]	...	...	...	2·10
Sb ₂ O ₅	...	...	...	·50
Cl	...	...	...	20·00
				99·24

To deduce a formula from these figures it is necessary to assume an unlikely combination such as,—



⁷ Twelvetrees—Rept. Secy. Mines Tas., 1900-1 (1901), p. 356, pl.;
Id.—Proc. Roy. Soc. Tas., 1900-1 (1902), p. 51, pl.

otherwise we must suppose that the mineral contains 20 % of free chlorine.

When this difficulty was pointed out to Mr. Petterd, whose enthusiasm in mineralogical research is well known, he generously gave me permission to make a new analysis of his material. The result has been to show that, by some mischance, the percentages for chlorine and arsenic pentoxide have been transposed. To this accidental circumstance, and the somewhat unusual crystal habit, we owe the name *petterdite*, which must now lapse into the synonymy of *mimetite*, where it may perhaps be retained for crystals of a habit similar to this (Pl. xxxi., fig. 4).

Two partial analyses were made. In I, .5589 gram was taken, dissolved in cold, dilute nitric acid and the chlorine precipitated by silver nitrate. The silver chloride obtained weighed .0557 gram, giving 2.46 % chlorine. From the filtrate silver was removed by hydrochloric acid in slight excess and lead thrown down by sulphuric acid in alcoholic solution, the precipitate being subsequently treated in the crucible with sulphuric acid to convert any lead chloride into sulphate. The lead sulphate weighed .5861 gram, equivalent to 77.16 % oxide. Alcohol was evaporated from the filtrate by gentle heat and arsenic and phosphoric acids precipitated together by "magnesia mixture." The precipitate was approximately weighed after gentle ignition (reckoned as pure *pyro-arsenate* it was equivalent to about 22 % arsenic pentoxide), redissolved in hydrochloric acid and a current of sulphuretted hydrogen passed through the solution. A bulky yellow precipitate of sulphide of arsenic came down and was filtered off. Part of this was accidentally lost in oxidising to arsenic acid; the remainder was thrown down by "magnesia mixture," and ignited with addition of some ammonium nitrate crystals; it weighed .0803 gram, giving 10.63 % arsenic pentoxide. The filtrate from sulphide of arsenic was concentrated and phosphoric acid estimated by precipitation with "magnesia mixture"; magnesium *pyro-phosphate* weighed .0222 gram, equal to 2.53 % phosphorus pentoxide. Hence we may put arsenic pentoxide as comprising 18 or 19 %.

For analysis II, .6391 gram was dissolved in nitric acid, the solution evaporated on the water bath, lead thrown down by sulphuric acid and filtered off. From the filtrate, arsenic and the remaining traces of lead were removed by sulphuretted hydrogen, treated with sodium sulphide solution, the small residue of lead sulphide filtered off, converted into sulphate and added to the main portion, the total weight being .6699 gram, making 77.12 % oxide of lead. In the filtrate from lead

sulphide, arsenic was precipitated by addition of hydrochloric acid, oxidised by strong nitric acid and estimated as magnesium pyro-arsenate, which weighed 1550 gram, yielding 17.95% arsenic pentoxide. Phosphorus was estimated as before in the filtrate from the sulphides of lead and arsenic. The result was 0.248 gram magnesium pyro-phosphate, equivalent to 2.47% phosphorus pentoxide.

Antimony if present would be left on the solution of sulphide of arsenic in nitric acid but its presence was not proved.

Thus we arrive at the conclusion that petterdite is really mimetite containing an appreciable amount of phosphoric, isomorphously replacing arsenic acid; chemically it would be classed with the variety campylite, and it is noteworthy that Twelvetrees mentions campylite as sometimes associated with petterdite,⁸ while Petterd in another place alludes to campylite as occurring in pale, *almost white* crystals at the Britannia Mine.⁹

The result of analyses is tabulated below; III is the mean of analyses I and II, under IV is given for comparison Rammelsberg's analysis of campylite from Cumberland, England,¹⁰ while V is the theoretical composition for 2 (3 Pb₃ P₂ O₈. Pb Cl₂) + 7 (3 Pb₃ As₂ O₈. Pb Cl₂).

	I.	II.	III.	IV.	V.
Cl ...	2.46	not det.	2.46	2.41	2.44
P ₂ O ₅ ...	2.53	2.47	2.50	3.34	3.25
As ₂ O ₅	not det.	17.95	17.95	18.47	18.40
Pb O ...	77.16	77.12	77.14	76.97	76.47
			100.05	101.19	100.56

The angular measurements obtained from petterdite may now be compared with the angles given by Goldschmidt for mimetite.

⁸ Twelvetrees—*Loc. cit.*

⁹ Petterd—*Proc. Roy. Soc. Tas.*, 1902 (1903), p. 20.

¹⁰ Rammelsberg—*Pogg. Ann.*, xci., 1854, p. 316.

Forms.		Measured.		Calculated.		Difference.		No. of observations.
		ϕ	ρ	ϕ	ρ	ϕ	ρ	
<i>c</i>	0001	—	—	—	—	—	—	—
<i>m</i>	10 $\bar{1}$ 0	0 15	90 6	0 0	90 0	0 15	0 6	8
<i>x</i>	10 $\bar{1}$ 1	0 17	38 42	0 0	40 2	0 17	1 20	7
<i>s</i>	11 $\bar{2}$ 1	30 43	53 20	30 0	55 30	0 43	2 10	5

The agreement, especially for the important 0001 \wedge 10 $\bar{1}$ 1 and 0001 \wedge 11 $\bar{2}$ 1, is by no means close, but a considerable latitude may be claimed on account of the poor quality of material and the small number of observations, which were limited by my desire to mutilate a handsome specimen (Pl. xxxii.) as little as possible.

CROCOITE,

MAGNET MINE, TASMANIA.

(Plate xxxi., fig. 5).

Of this mineral I have examined five specimens with crystals *in situ*, four lent by Mr. W. F. Petterd and one by Mr. G. W. Card, also a number of loose crystals belonging to Mr. Petterd.

The matrix is a rather friable limonite in which the crocoite is partly embedded. The largest specimen carries numerous crystals averaging about 2 mm. in length; in the other cases where *in situ* the crystals are quite minute and had previously been referred to carminite (arsenate of lead and iron) by Petterd,¹¹ who however informed me in forwarding the specimens that he doubted whether this identification was correct. Qualitative analysis proves their composition to be chromate of lead, and, like the larger crystals, they agree morphologically with crocoite. Hence carminite must be deleted from the list of Tasmanian minerals. Of the loose crystals, which are all imperfect, some measure about 10 mm. in length.

The habit is remarkably constant throughout, the crystals being prismatic by extension along the zone axis *b t* (Pl. xxxi., fig. 5). This zone being the only well-developed one was made equatorial and a stereogram constructed from the co-ordinate angles obtained;

¹¹ Petterd—Proc. Roy. Soc. Tas., 1902 (1903), p. 20.

from this the forms were identified by means of Penfield's protractors and the identification was confirmed by calculation of the normal angles. All the faces are small with the exception of t (111) which gives an excellent image, and a peculiar rounded face which could not be determined but is possibly x (301); the pinacoid b (010) is very small when present.

The table contains some of the results of measurement compared with the theoretical angles given by Goldschmidt.

Forms.	Calculated from Measurements.	Calculated from Winkeltabellen.	Difference.
$b : m = 010 : 110$	46 43	46 51	8
: $t = \quad : 111$	59 35	59 36	1
: $v = \quad : \bar{1}11$	53 38	53 49	11
: $k = \quad : \bar{1}01$	89 44	90 0	16
$m : t = 110 : 111$	34 3	33 56	7
$m' : v = \bar{1}10 : \bar{1}11$	40 51	40 38	13

DATOLITE.

COLEBROOK MINE, DUNDAS, TASMANIA.

(Plate xxxiii.).

This mineral was first obtained in sinking a shallow shaft in the western portion of the limurite outcrop.¹² It is found associated with axinite, calcite and other minerals as already described under axinite, and sometimes occurs in large brilliant crystals. It is colourless, greenish or yellowish.

Crystallography. The crystals have mutually interfered during growth, but one small projecting crystal was found and measured. This crystal is shown in ideal and actual development in Pl. xxxiii., figs. 1-4; fig. 5 shows the distribution of forms and the chief zones.

The habit of the figured crystal seems characteristic so far as can be judged by inspection of others: it is prismatic by extension parallel to the a axis and measures about 6 mm. in length. It is fairly rich in forms, but as is usual with datolite many of the faces are wavy and give poor reflections; the three faces ι ($\bar{2}12$), π ($\bar{2}31$), and x (102) are dull and were measured in the position of maximum illumination.

As in the case of axinite, Goldschmidt and Dana choose

¹² Petterd—Proc. Roy. Soc. Tas., 1897 (1898), p. 63.

different positions and axes. The crystal was mounted on the goniometer with Goldschmidt's prism zone equatorial so that the measured, could be directly compared with the calculated angles; the indices were transformed to Dana's axes by the equations $h' = l$, $k' = -k$, $l' = 2h$. The angles are tabulated below.

Form.		Measured.		Calculated.		Difference.	
Goldschmidt.	Dana.	ϕ	ρ	ϕ	ρ	ϕ	ρ
<i>a</i>	100	90	0	90	0	0	0
<i>c</i>	001	90	3	90	0	10	9
<i>t</i>	013	67	3	67	7	8	3
<i>m</i>	011	38	5	38	18	5	3
<i>M</i>	110	0	28	0	14	37	5
<i>r</i>	102	90	44	90	0	24	4
<i>l</i>	212	-56	32	-57	32	11	31
<i>e</i>	112	-57	49	-57	36	13	11
<i>n</i>	111	38	39	38	27	12	1
<i>μ</i>	114	-72	64	-72	25	15	26
<i>κ</i>	115	-75	68	-75	46	2	41
<i>λ</i>	113	-67	57	-67	5	13	1
<i>π</i>	231	-13	43	-14	36	56	56

Composition. The method of analysis is that described by Gooch¹³ with modifications suggested by Penfield and Sperry,¹⁴ boric anhydride being distilled with alcohol, caught in strong ammonia solution, transferred to a basin and evaporated over lime as described in a former paper.¹⁵ For this determination 1.1478 gram was fused with sodium carbonate, exhausted with water, filtered, the filtrate acidified with nitric acid and distilled. Water was determined directly in a Penfield tube on .6108 gram mixed with previously ignited lime to minimise the risk of expelling boric anhydride. The other constituents were estimated in another portion weighing about a gram. The result of analysis is appended (I) together with an analysis by Whitfield¹⁶ of datolite from Bergen Hill, New Jersey (II).

	I.	II.
H ₂ O	6.48 %	6.14 %
Si O ₂	36.28	35.74
Al ₂ O ₃} } ... ..	.95	.31
Fe ₂ O ₃ }		
Fe O		
Ca O	35.21	35.14
B ₂ O ₃	20.48	22.60
	99.40	99.93

In conclusion I have to acknowledge my indebtedness to Messrs. W. F. Petterd and D. A. Porter, for the loan of specimens and for much valuable information, and to Professor T. W. E. David, B.A., Trustee, for permission to use the goniometer in the Geological Department of the University of Sydney.

¹³ Gooch—Bull. U.S. Geol. Survey, No. 42, 1882, p. 64.

¹⁴ Penfield and Sperry—Am. Journ. Sci., (3), xxxiv., 1887, p. 222.

¹⁵ Anderson—Rec. Austr. Mus., v., 1904, p. 128.

¹⁶ Whitfield—Bull. U.S. Geol. Survey, No. 55, 1889, p. 59.